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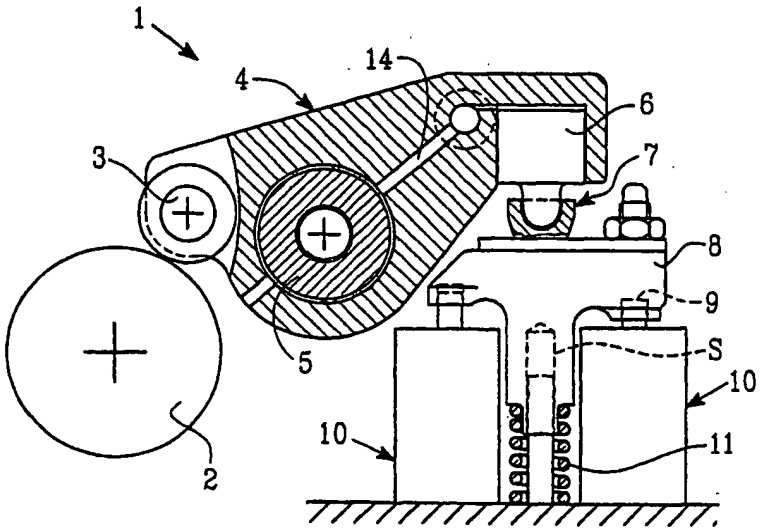
(54) Title: ENGINE BRAKE APPLICATION SYSTEM



(57) Abstract

An engine brake application system for an internal combustion engine. The engine has at least one cylinder, at least one exhaust valve associated with the cylinder, and a rocker arm (4) for activating the exhaust valve. The rocker arm is arranged on a hollow rocker arm shaft (5). The engine brake application system includes means (12) for regulating oil pressure in the hollow rocker arm shaft (5) and means (6; 15) responsive to an increase in oil pressure in the hollow rocker arm shaft (5) and incorporated in the rocker arm (4) for taking up clearance between the rocker arm and the exhaust valve. To effect a reduction of engine speed during a gear shift, the system includes means (16; 17) responsive to a signal generated in response to a need to effect a gear shift for rapidly increasing the oil pressure in the hollow rocker arm shaft (5) to thereby effect valve clearance take-up.

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TITLE: Engine brake application system

TECHNICAL FIELD:

The present invention relates to an engine brake application system according to the preamble of claim 1 and to a method of reducing engine speed of an internal combustion engine during gear shifts. The invention further relates to the use of valve clearance take-up means to effect engine braking.

BACKGROUND OF THE INVENTION:

Commercial vehicles such as trucks and buses are increasingly being fitted with automatic or semi-automatic gearboxes. Such gearboxes can be likened to conventional manual gearboxes, with the difference that gear shifting is performed by actuators rather than manually by the driver. Appended Fig. 1 represents the principal phases of an upshift (i.e. to a higher gear) with such a gearbox. Fig. 1 is a comparison of engine torque and engine speed with respect to time. Phase "a" represents a normal operating condition prior to instigation of a gearshift. Phase "b" represents torque removal once it has been determined that an upshift is to take place. Phase "c" represents disengagement of a dog clutch to disconnect the gearbox from the engine. Phase "d" represents reduction of engine speed to match the engine speed with the gear ratio to be selected. Once the engine speed has been reduced sufficiently, the new gear can be engaged. Thus, phase "e" represents engaging the new dog clutch. Phase "f" represents reapplication of torque and phase "g" represents a normal operating condition after the gearshift has taken place.

In order to reduce loss of momentum of the vehicle during an upshift, it is advantageous if the engine speed can be matched with the new gear ratio as quickly as possible. It is known from SE-C-502 154 to selectively apply an exhaust gas brake during an upshift when certain operating parameters are attained to thereby effect a rapid reduction of the engine speed. In this manner, wear on the exhaust gas brake system is said to be reduced since application of the exhaust gas brake occurs only during a small fraction of the total number of upshifts.

An auxiliary braking system for commercial vehicles is known from US-A-5 193 497 in which an

internal combustion engine is provided with a device for taking up valve clearance in the valve mechanism of the engine. The take-up occurs by means of an actively adjustable, hydraulically operated take-up means operable between two positions, namely a withdrawn position and an extended position, which take-up means is arranged at the operating end of the rocker arms whose valve clearance is to be taken up. In a manner described in detail in said document, the engine's existing pressurized oil system is used in order to guarantee operation of the device.

The auxiliary braking system disclosed in the above-mentioned US-A-5 193 497 has enjoyed considerable commercial success. Due, however, to the relatively long time it takes for the take-up means to attain its extended position, the system of US-A-5 193 497 is not suitable for use for reducing engine speed during upshifts.

SUMMARY OF THE INVENTION:

It is therefore an object of the present invention to provide an engine brake application system which incorporates the commercial advantages of the system described in US-A-5 193 497, and which is also suitable for use for reducing engine speed during upshifts.

This object is achieved in accordance with the present invention by the engine brake application system as claimed in appended claim 1.

It is a further object of the invention to provide a method for reducing engine speed during upshifts.

This object is achieved in accordance with the present invention by the method as claimed in claim 9.

The invention also provides for the use of valve clearance take-up means in an internal combustion engine to reduce engine speed during a gear shift.

Advantageous embodiments of the invention are detailed in the dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS:

The invention will be described in greater detail in the following by way of example only and

with reference to embodiments shown in the attached drawings, in which:

Fig. 1 is a graphical representation of the principal phases during a upshift in a gearbox;

Fig. 2 is a schematic representation of the valve clearance take-up device of US-A-5 193 497;

Fig. 3 is a schematic representation of the engine brake application system according to the present invention;

Fig. 4 is a sectional view through a first embodiment of a pneumatic actuator for use in the system of Fig. 3, and

Fig. 5 is a sectional view through a second embodiment of a pneumatic actuator for use in the system of Fig. 3.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS:

As previously mentioned above under Background of the Invention, Fig. 1 represents the principal phases of an upshift (i.e. to a higher gear) with the type of automatic or semi-automatic gearboxes presently used in commercial vehicles. Fig. 1 is a comparison of engine torque and engine speed with respect to time. Phase "a" represents a normal operating condition prior to instigation of a gearshift. Since phase "a" is prior to an upshift, the engine speed is normally increasing. Phase "b" represents torque removal once it has been determined that an upshift is to take place. Torque removal requires matching of the rotational speeds of the output shaft from the engine and the input shaft to the gearbox and can be effected in several ways depending on the prevailing operating conditions of the vehicle to which the gearbox is fitted. Phase "c" represents disengagement of a dog clutch to disconnect the gearbox from the engine. During this phase, the supply of fuel to the engine is restricted to prevent the engine speed from increasing. Phase "d" represents reduction of engine speed to match the engine speed with the gear ratio to be selected. It is primarily the delay in reaching the desired new engine speed which determines how quickly an upshift can take place. Once the engine speed has been reduced sufficiently, the new gear can be engaged. Thus, phase "e" represents engaging the new dog clutch. Phase "f" represents reapplication of torque and phase "g" represents a normal operating condition after the gearshift has taken place.

In accordance with the present invention, reduction of engine speed under phase "d" is attained using a modified version of the valve clearance take-up mechanism disclosed in US-A-5 193 497, the contents of which are hereby incorporated by reference. The principle of operation of the valve clearance take-up mechanism disclosed in said document can be gleaned from Fig. 2. Thus, in said drawing, a valve mechanism 1 for an internal combustion engine is schematically shown. The mechanism 1 includes a camshaft 2 which, via a cylindrical roller 3, transmits its rotational movement to a rocker arm 4. The rocker arm 4 is arranged on a hollow rocker arm shaft 5 which is intended to be mounted to a not shown cylinder head by suitable means such as bolts. Displacement of the rocker arm 4 is transmitted via means 6 and a hemispherical guide 7 to a yoke 8 which is movable up and down on a guide S in the cylinder head. In the illustrated embodiment, the yoke 8 acts on two valve stems 9. Each valve stem is surrounded in a conventional manner by a valve spring 10. In additional to both the valve springs 10, there is a spring 11 which is arranged beneath the yoke 8. The purpose of this spring is to maintain the yoke in such a position that the clearance which always arises in a valve mechanism of this type occurs between the respective valve stems 9 and the underside of the yoke 8.

With reference to Fig. 3, the described valve mechanism is pressure lubricated by oil which is supplied to the hollow interior of the rocker arm shaft 5 via a pressure regulator 12. The pressure regulator is supplied with oil at a pressure of, for example, 5 bar and the pressure of oil delivered to the rocker arm shaft is controlled by signals from an engine management system (EMS) 13. Oil returns to the engine sump as a result of leakage flow between the rocker arm shaft 5 and the various bearings. Referring back to Fig. 2, oil introduced into the rocker arm shaft 5 flows along a conduit 14 in each rocker arm 4 to act on the means 6 arranged at the end of the rocker arm above the valve stems 9. The means 6 is in the form of a piston 15 which is operable between two positions, namely a withdrawn position and an extended position. During normal operating conditions, the pressure regulator 12 supplies oil to the rocker arm shaft 5 at about 1 bar. Under such pressure conditions, the piston 15 is retained in its withdrawn position by means of the spring 11 acting on the yoke 8.

When it is desired to take up the valve clearance, i.e. when auxiliary braking is required, the EMS 13 instructs the pressure regulator 12 to supply oil to the rocker arm shaft 5 at an increased pressure of, for example, 2 bar. Build-up of oil pressure adjacent the piston 15 in the rocker arm 4 causes displacement of the piston through a swept volume to its extended position. In its extended

position, the piston reduces the valve clearance in such a manner that the rocker arm is actuated by not shown small lobes on the camshaft 2. This implies that the exhaust valves can be operated to obtain negative work from the engine, i.e. an engine braking effect.

Whilst the above-described system does offer a certain amount of engine braking, it takes simply too long a time for the piston to reach its extended position for the system to be used as an engine brake application system during gear shifting. Thus, in accordance with the present invention, the rocker arm shaft 5 cooperates with means 16 responsive to a signal generated in response to a need to effect a gear shift for rapidly increasing the oil pressure in the hollow rocker arm shaft to thereby effect valve clearance take up.

The expression "rapidly increasing the oil pressure" means that the oil pressure in the hollow rocker arm must be increased sufficiently quickly for the valve clearance take-up to be attained such that a discernable amount of engine braking is obtained during phase "d" of Fig. 1. It will be apparent to the skilled person that the actual rate of increase of pressure will depend i.a. on the viscosity of the oil, the number of rocker arms equipped with the valve clearance take-up means, etc.

The means 16 responsive to a signal generated in response to a need to effect a gear shift for rapidly increasing oil pressure in the hollow rocker arm shaft to thereby effect valve clearance take up preferably comprises a pneumatic actuator. The pneumatic actuator is arranged to inject a volume of oil into the hollow rocker arm shaft 5, with the volume of oil corresponding substantially to the swept volume through which the piston 15 (or pistons if a plurality of rocker arms are provided with valve clearance take-up means) is displaced when effecting valve clearance take-up. In a typical application, the volume of oil may be about 1 dl.

Thus, one embodiment of a pneumatic actuator suitable for use in the system of the present invention is illustrated in Fig. 4. The pneumatic actuator 17 comprises a generally cylindrical housing 18 closed at one end by an end cap 19. An oil displacement means in the form of a piston 20 is displacable within the cylindrical housing 18 between a rest position and an activated position. The piston 20 is urged towards the rest position by return means which may be in the form of resilient means, for example a helical spring 21, acting on an end wall 22 of the cylindrical housing opposite the end cap 19. Accordingly, the spring 21 is accommodated in a

chamber 23 delimited in part by the cylindrical housing 18, the piston 20 and the end wall 22. It is to be understood, however, that the return means may comprise any means which will ensure a rapid return of the oil displacement means from its activated position to its rest position. Such means can, for example, include compressed air. The end wall 22 is provided with a through opening 24 such that the chamber 23 communicates with the inside of the hollow rocker arm shaft 5. Thus, the chamber 23 is filled with oil.

The end cap 19 is provided with a through opening 25 which selectively communicates with a high pressure pneumatic source, for example the pressurized air system of the vehicle to which the engine brake application system is fitted. As shown in Fig. 3, the pneumatic source may be an air accumulator 26 which is supplied with air at, for example, 8 bar. The air accumulator 26 is separated from the pneumatic actuator 17 by a suitable electrically triggered valve means 27. The valve means 27 is arranged to connect the through opening 25 of the actuator 17 to the air accumulator 26 upon receipt of a signal from the EMS 13 that engine braking is required during an upshift.

In an alternative embodiment of a pneumatic actuator shown in Fig. 5, a flexible membrane 28 is used as oil displacement means. Thus, the flexible membrane is affixed within a cylindrical housing 29 to thereby partially define an air chamber 30 and an oil chamber 31. The air chamber communicates via a first end cap 32 with a high pressure pneumatic source, whilst the oil chamber 31 communicates with the interior of the hollow rocker arm shaft 5 via a second end cap 33. The high pressure pneumatic source may by any of those described with relation to the embodiment shown in Fig. 4. The membrane 28 may be made of any suitably resilient material, preferably a polymer. Application of air pressure in the air chamber 30 causes the membrane to displace oil out of the oil chamber 31 and into the hollow rocker arm shaft. Depending on the material properties of the membrane 28, its natural resiliency may make a return spring superfluous. Thus, the membrane may also serve as return means.

Irrespective of the oil displacement means, the system is preferably adapted to displace the oil displacement means from its rest position to its activated position in no more than 0.8 seconds. Advantageously, this time interval should be less than 0.5 seconds, preferably less than 0.2 seconds, for example 0.1 seconds, and most preferably about 0.05 seconds. Furthermore, the return means should be adapted to displace the oil displacement means from its activated

position to its rest position in a similar time interval. In this manner, sufficiently quick activation and deactivation of the engine brake application system for useful engine braking during upshifting is ensured.

The system according to the present invention functions in the following manner.

During normal operation of the vehicle to which the system of the present invention is fitted, oil is supplied to the hollow rocker arm shaft 5 at about 1 bar. Thus, the piston 15 in each rocker arm 4 is in its withdrawn position. When auxiliary braking is desired to retard the velocity of the vehicle, the EMS 13 instructs the pressure regulator 12 to supply oil to the hollow rocker arm shaft 5 at a pressure of about 2 bar. As previously explained, this increase in pressure causes the piston 15 to gradually approach its extended position at which valve clearance is taken up.

During normal operation of the vehicle, when the EMS 13 determines that an upshift is to take place and engine brake application is necessary to expedite the upshift, the EMS instructs the pressure regulator 12 to increase the pressure of oil supplied to the hollow rocker arm shaft 5 as when normal auxiliary braking is required. In addition, the EMS 13 signals the electrically triggered valve means 27 to open. Compressed air is then able to rapidly flow into the pneumatic actuator to effect displacement of the oil displacement means, be it a piston or a membrane. A volume of oil is thereby rapidly injected into the hollow rocker arm shaft, causing the piston 15 at the end of each rocker arm to virtually spontaneously adopt its extended position, thereby taking up the valve clearance. Once the engine speed has been synchronised with the gear ratio to be engaged, the valve means 27 is instructed by the EMS 13 to connect the air side of the pneumatic actuator to atmosphere, thereby allowing the oil displacement means to return to its rest position. This return displacement rapidly reduces the oil pressure in the hollow rocker arm shaft 5 such that the piston 15 in each rocker arm is rapidly drawn back to its withdrawn position. Hence engine braking ceases and torque can be re-applied without undue delay, thereby maintaining the momentum of the vehicle.

The invention is not restricted to the embodiments described above and shown in the drawings, but may be varied within the scope of the appended claims. For example, the air accumulator 26 may be replaced by a direct connection to the compressed air system of the vehicle.

CLAIMS

1. An engine brake application system for an internal combustion engine, said engine having at least one cylinder, at least one exhaust valve associated with said cylinder, and a rocker arm (4) for activating said exhaust valve, said rocker arm being arranged on a hollow rocker arm shaft (5), said engine brake application system comprising:

means (12) for regulating oil pressure in said hollow rocker arm shaft (5);

means (6;15) responsive to an increase in oil pressure in said hollow rocker arm shaft (5) and incorporated in said rocker arm (4) for taking up clearance between said rocker arm and said exhaust valve;

characterized by means (16;17) responsive to a signal generated in response to a need to effect a gear shift for rapidly increasing said oil pressure in said hollow rocker arm shaft (5) to thereby effect valve clearance take-up.

2. The system as claimed in claim 1, characterized in that said means responsive to a signal generated in response to a need to effect a gear shift for rapidly increasing said oil pressure in said hollow rocker arm shaft (5) comprises a pneumatic actuator (17).

3. The system as claimed in claim 2 in which said means responsive to an increase in oil pressure for taking up clearance between said rocker arm and said exhaust valve comprises a piston (15) arranged for displacement through a swept volume between a withdrawn position and an extended position, characterized in that said pneumatic actuator (17) is arranged to inject a volume of oil into said hollow rocker arm shaft (5), said volume of oil corresponding substantially to said swept volume.

4. The system as claimed in claim 2 or 3, characterized in that said pneumatic actuator comprises an oil displacement means (20;28) displacable between a rest position and an activated position, said oil displacement means being urged towards said rest position by return means (21;28).

5. The system as claimed in claim 4, characterized in that said oil displacement means is a piston (20) and in that said return means is a resilient means such as a spring (21).

6. The system as claimed in claim 4, characterized in that said oil displacement means and said return means is a flexible membrane (28).

7. The system as claimed in any one of claims 4 to 6, characterized in that system is adapted to displace said oil displacement means (20;28) from its rest position to its activated position in less than 0.8 seconds, preferably less than 0.5 seconds, advantageously less than 0.2 seconds, more preferably less than 0.1 seconds and most preferably in about 0.05 seconds.

8. The system as claimed in any one of claims 4 to 6, characterized in that said return means (21;28) is adapted to displace said oil displacement means (20;28) from its activated position to its rest position in less than 0.8 seconds, preferably less than 0.5 seconds, advantageously less than 0.2 seconds, more preferably less than 0.1 seconds and most preferably in about 0.05 seconds.

9. A method for reducing engine speed of an internal combustion engine during gear shifts, said engine comprising at least one cylinder, at least one exhaust valve associated with said cylinder, a rocker arm (4) for activating said exhaust valve, said rocker arm being arranged on a hollow rocker arm shaft (5), means (12) for regulating oil pressure in said hollow rocker arm shaft (5) and means (6;15) responsive to an increase in oil pressure in said hollow rocker arm shaft and incorporated in said rocker arm for taking up clearance between said rocker arm and said exhaust valve, said method comprising the steps of:

generating a signal in response to a need to effect a gear shift, and

rapidly increasing said oil pressure in said hollow rocker arm shaft (5) in response to said signal to thereby effect valve clearance take-up.

10. The method of claim 9, wherein said signal is generated in an Engine Management System (13).

11. The method as claimed in claim 9 or 1, wherein said step of rapidly increasing said oil pressure in said hollow rocker arm shaft (5) is achieved using a pneumatic actuator (17).

12. Use of valve clearance take-up means in an internal combustion engine to reduce engine speed during a gear shift.

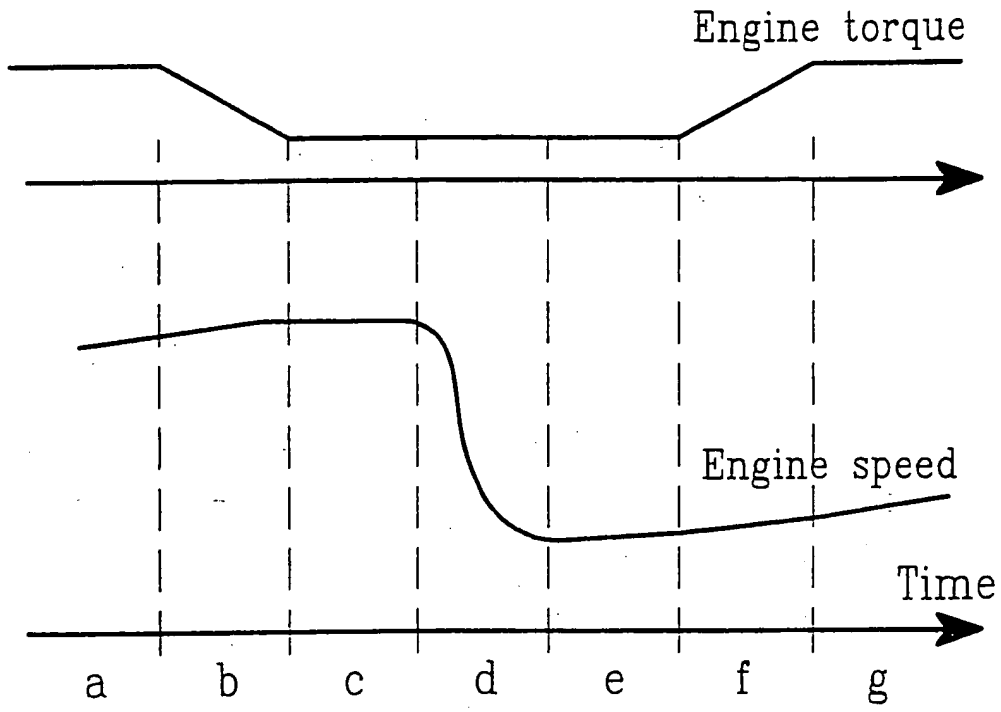
Engine torque
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FIG.1

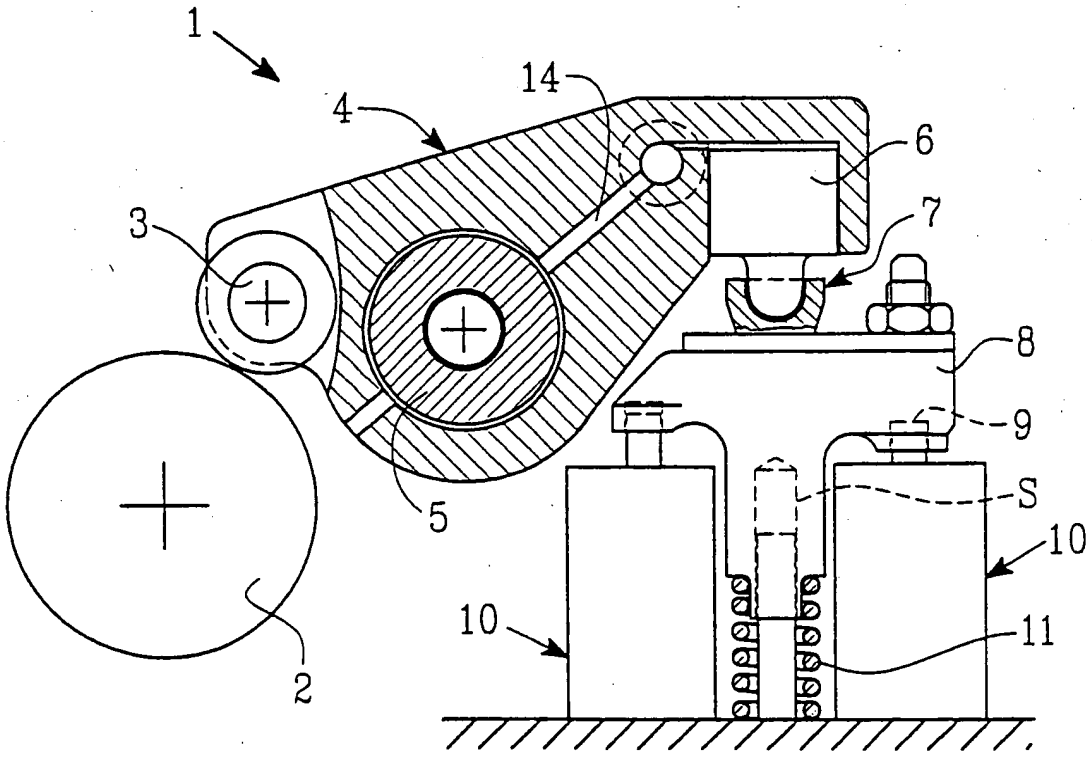
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FIG.2

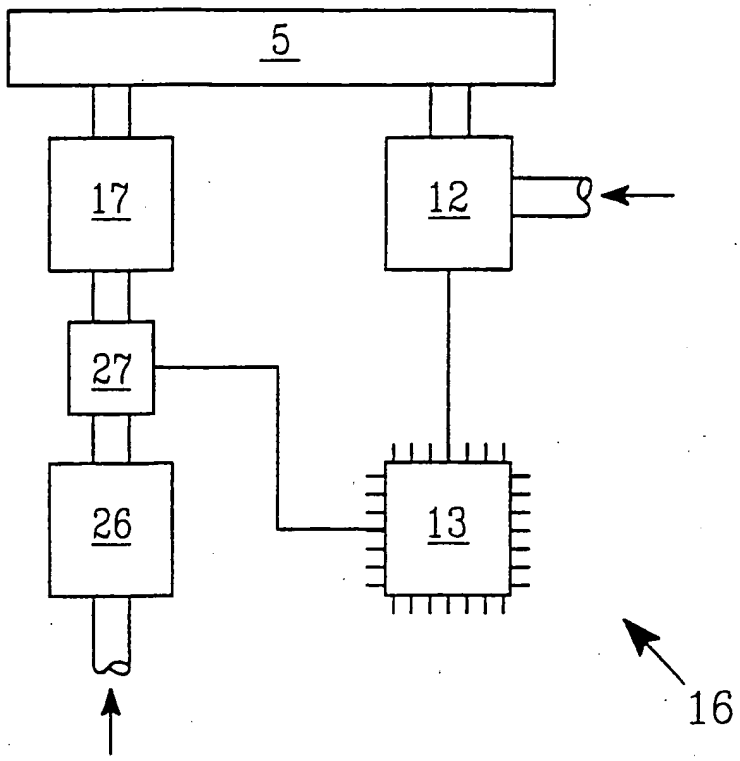

FIG.3

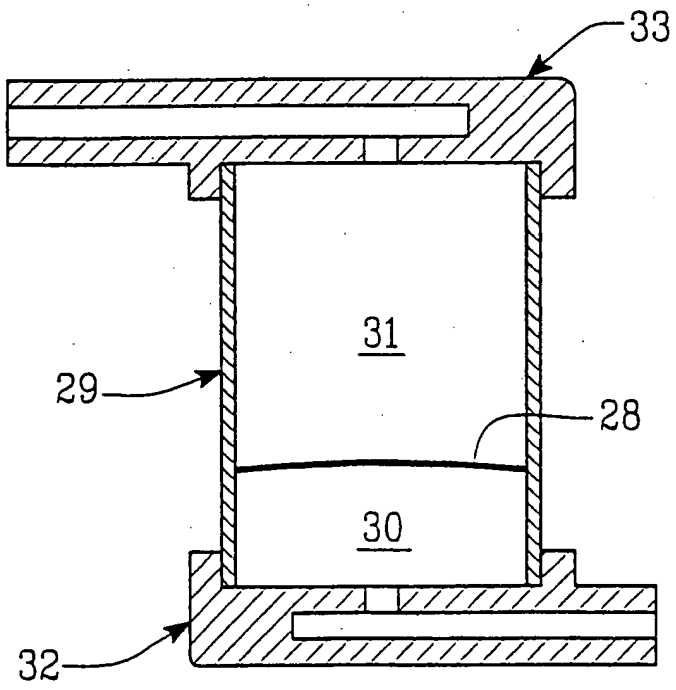

FIG.5

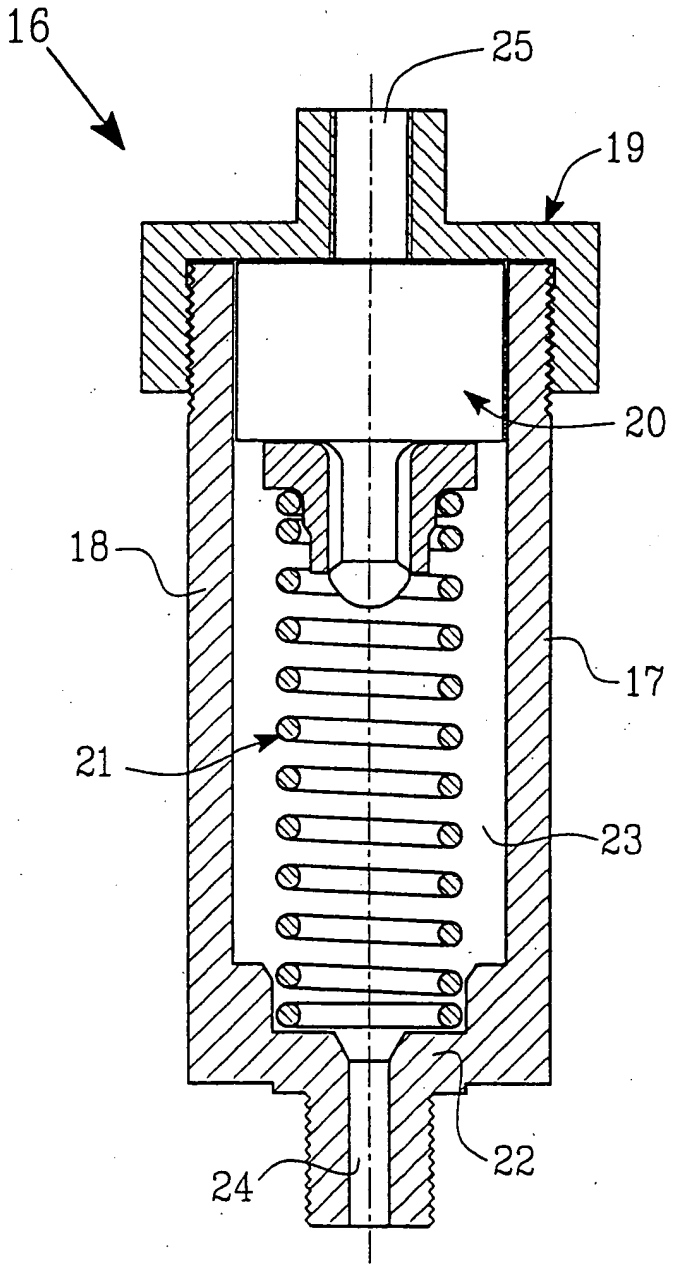

FIG.4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 99/02449

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: F02D 13/04, F01L 1/20, F01L 13/06, B60K 41/08
According to International Patent Classification (IPC) or to both national classification and IPC

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Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Date of the actual completion of the international search	Date of mailing of the international search report
9 February 2000	02 -03- 2000
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Dan Ionesco / JA A Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

Information on patent family members

02/12/99

International application No.
PCT/SE 99/02449

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